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(54) A molded applique product and a method of making the same

(57) A design is printed onto at least one surface of a flat substrate of synthetic resin, the printed substrate is formed into a three dimensional shape 20 and placed into a mould cavity of moulding tool 30 so as to fit securely therein, the front surface of the substrate being in contact with the mould surface and two flowable monomer solutions are simultaneously injected through gates 41, 42, 43 into the cavity 32 formed adjacent the back surface of the substrate so as to polymerise in situ and fuse with said back surface to form, on release from the mould, a three dimensional printed applique product.

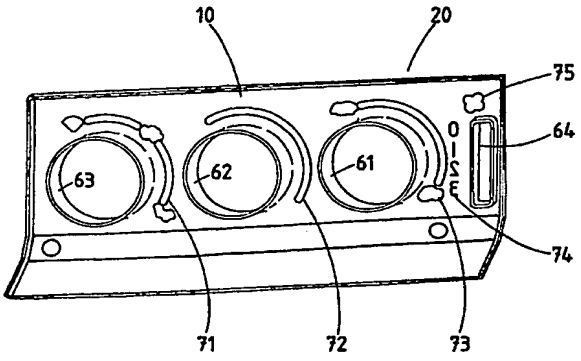

FIG.4

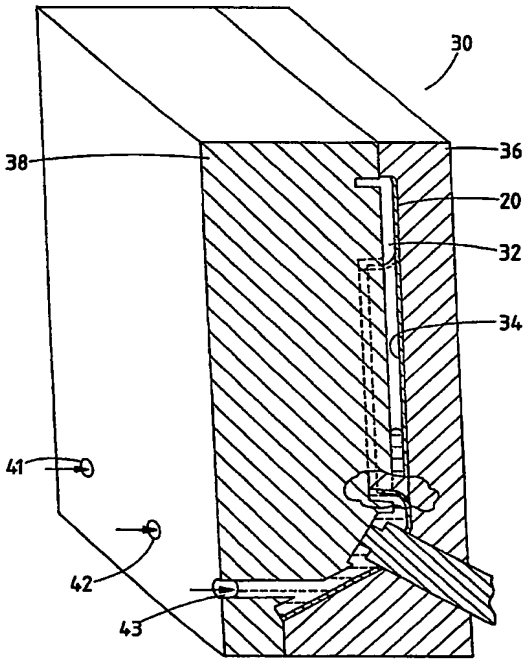

FIG.5

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

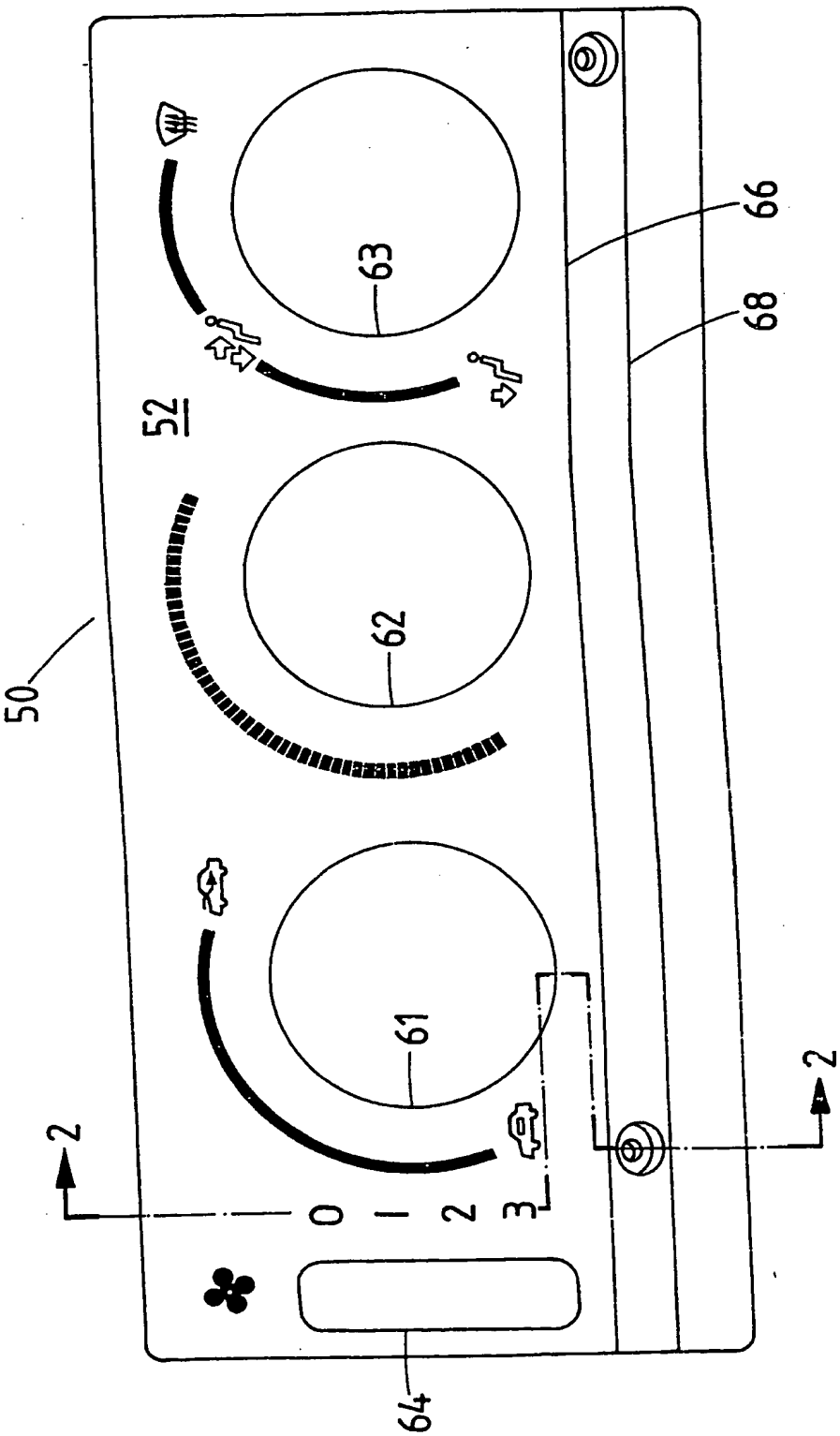


FIG.1

FIG. 2

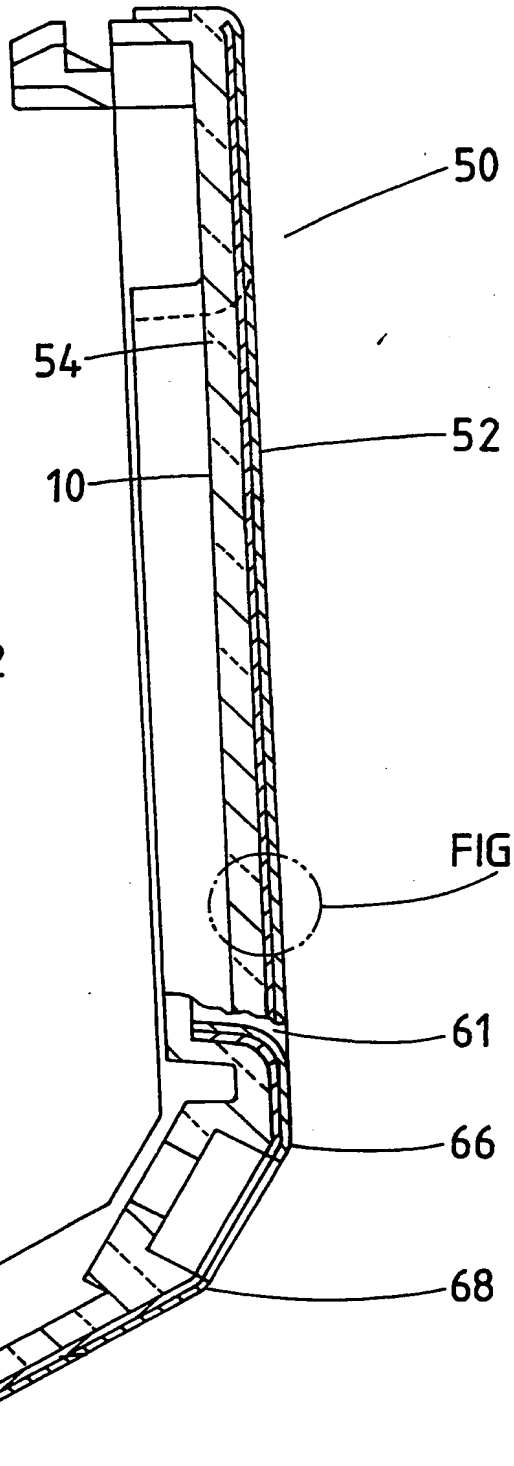


FIG. 2a

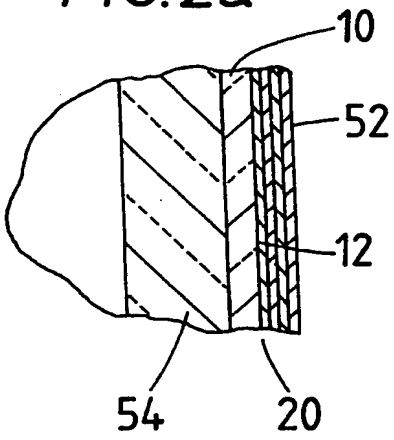
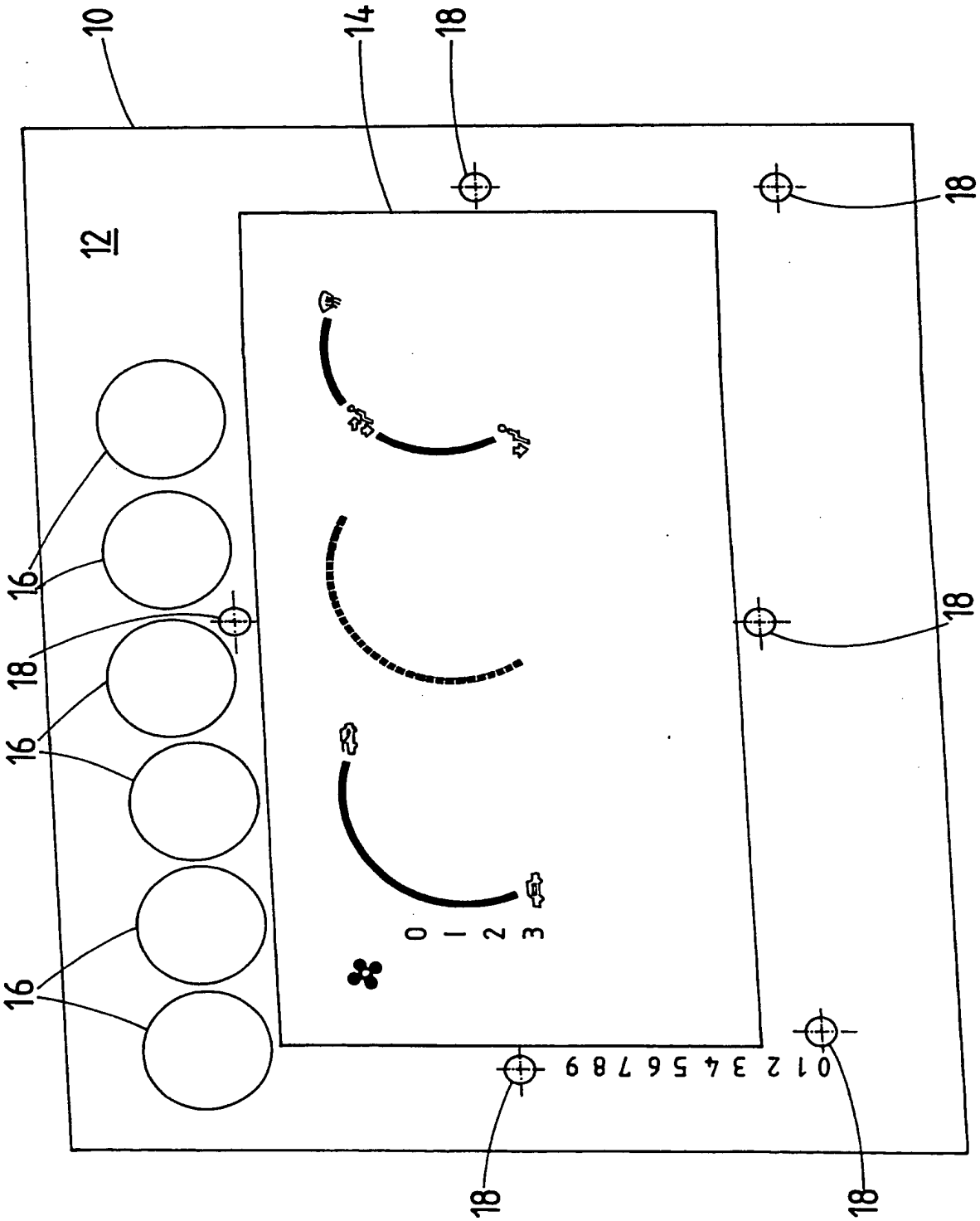


FIG.3



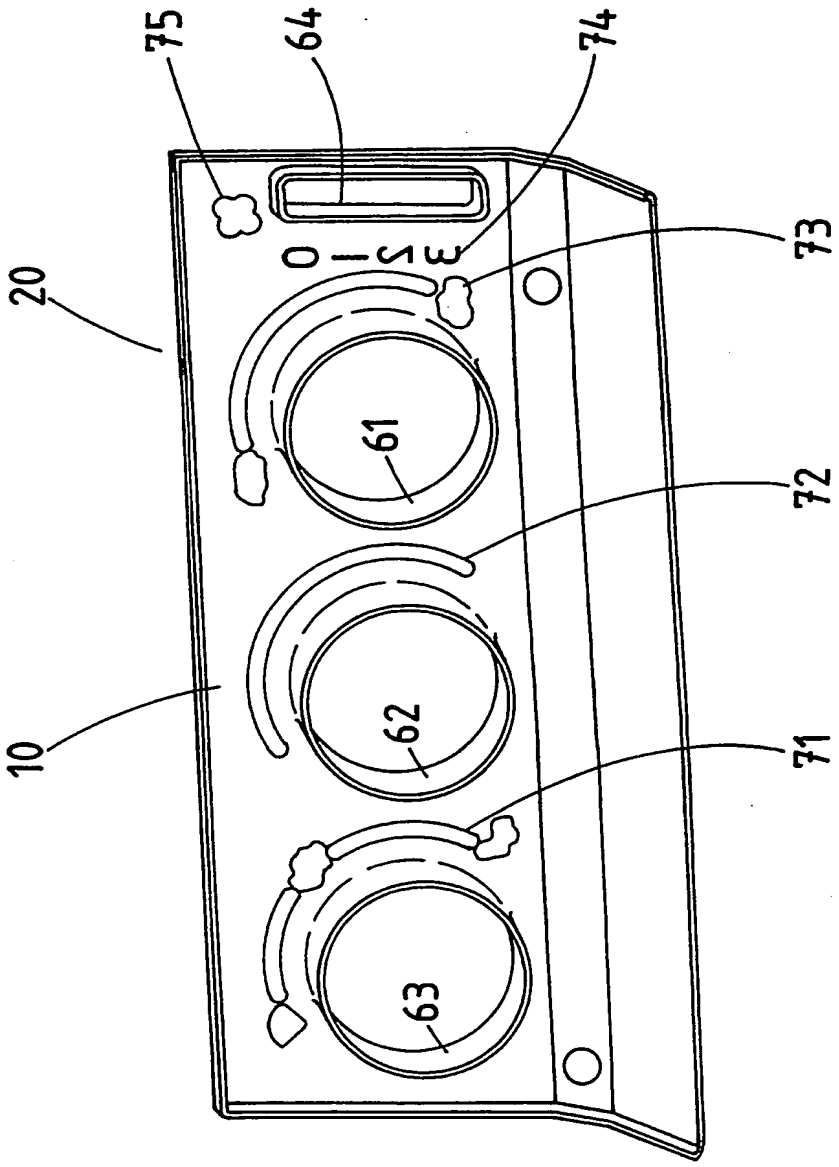


FIG.4

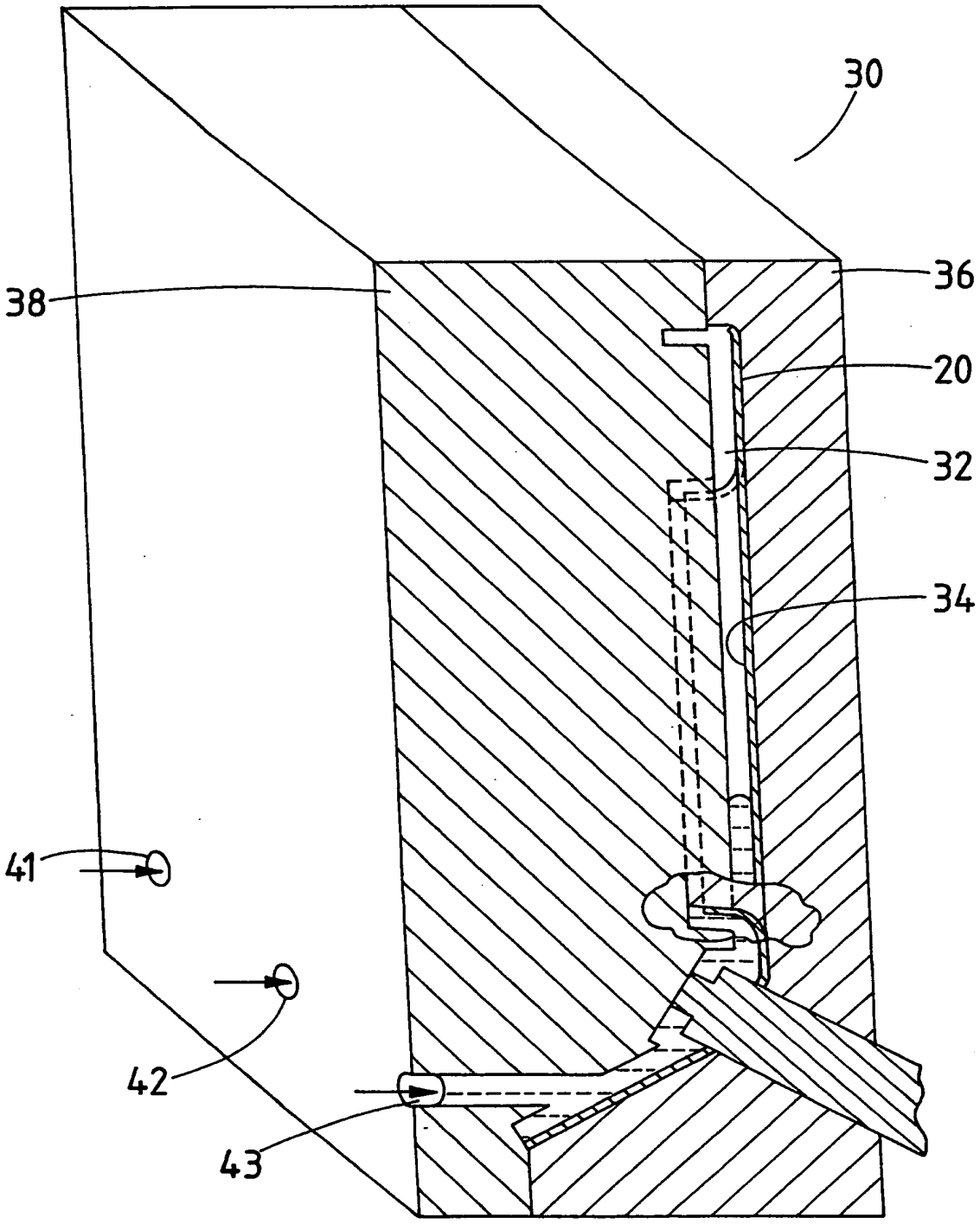


FIG. 5

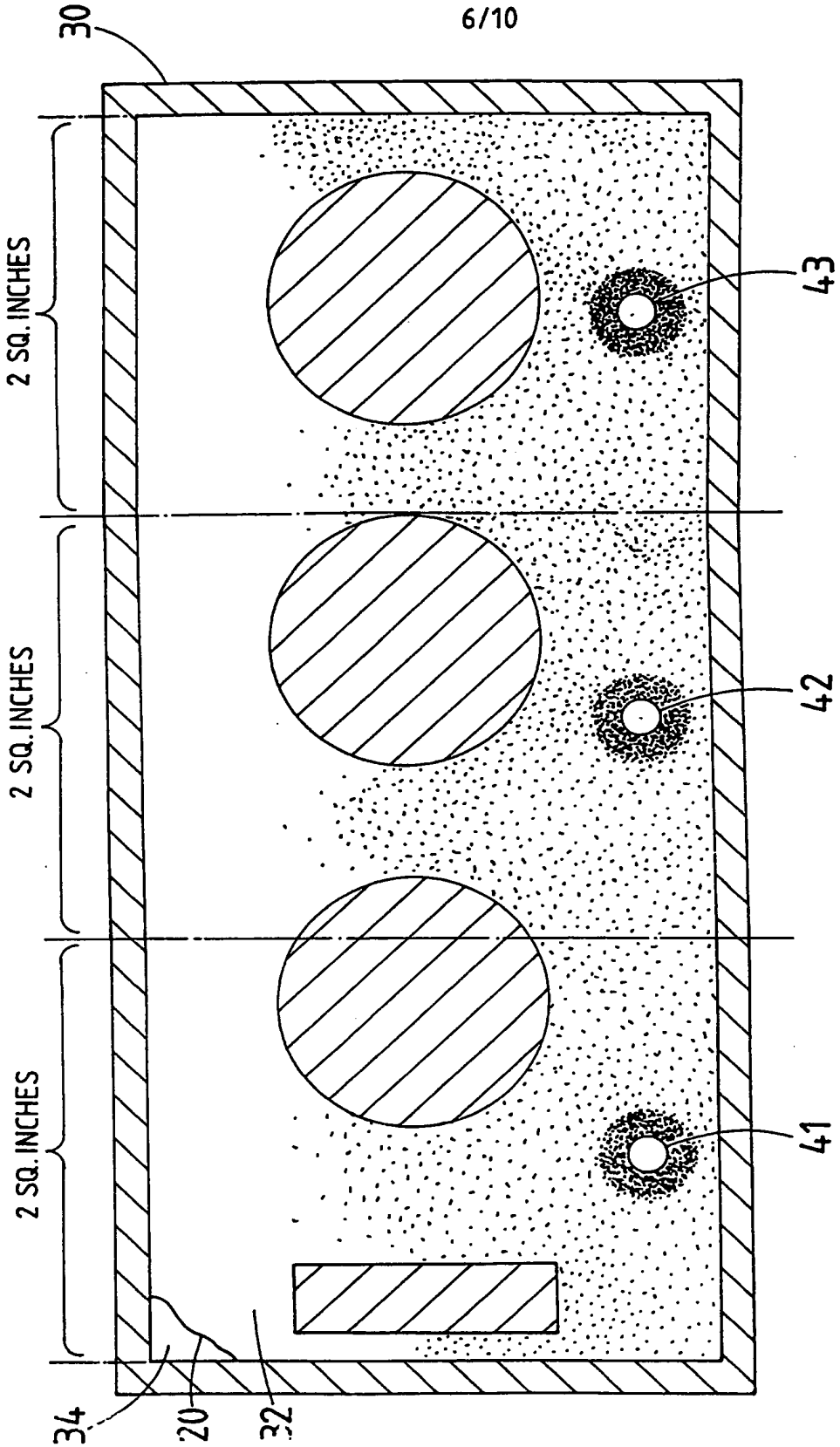


FIG.6

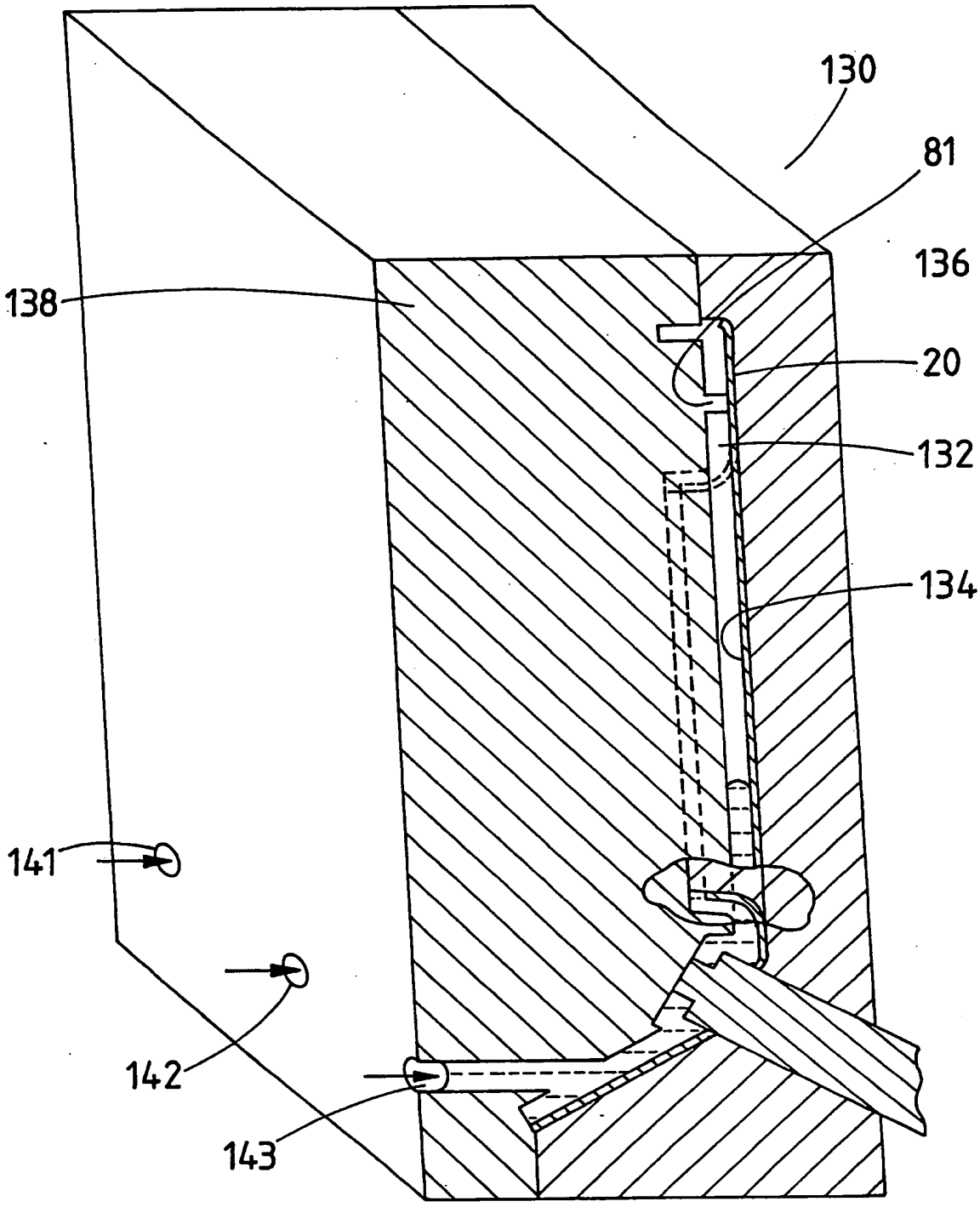


FIG.7

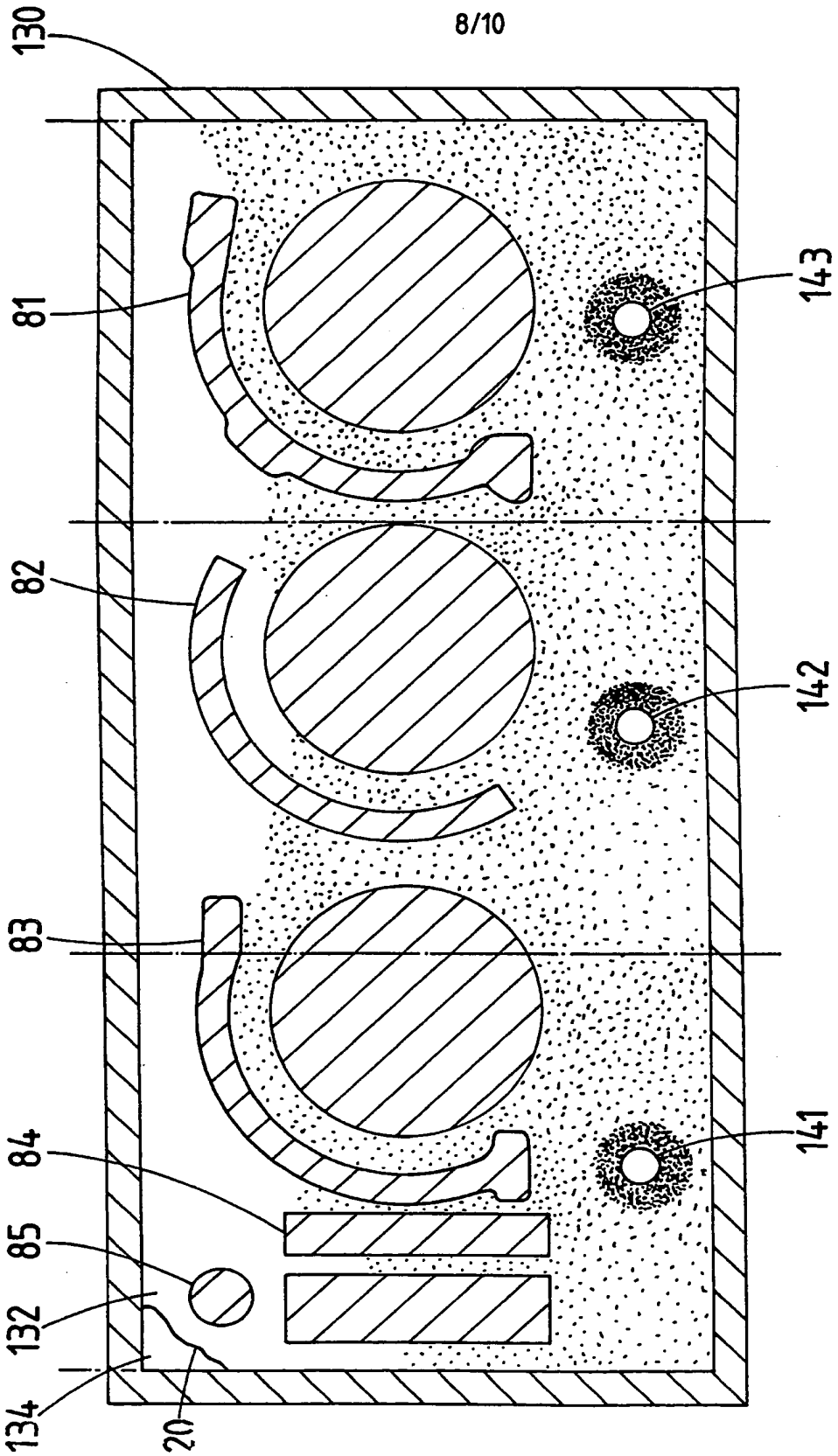


FIG.8

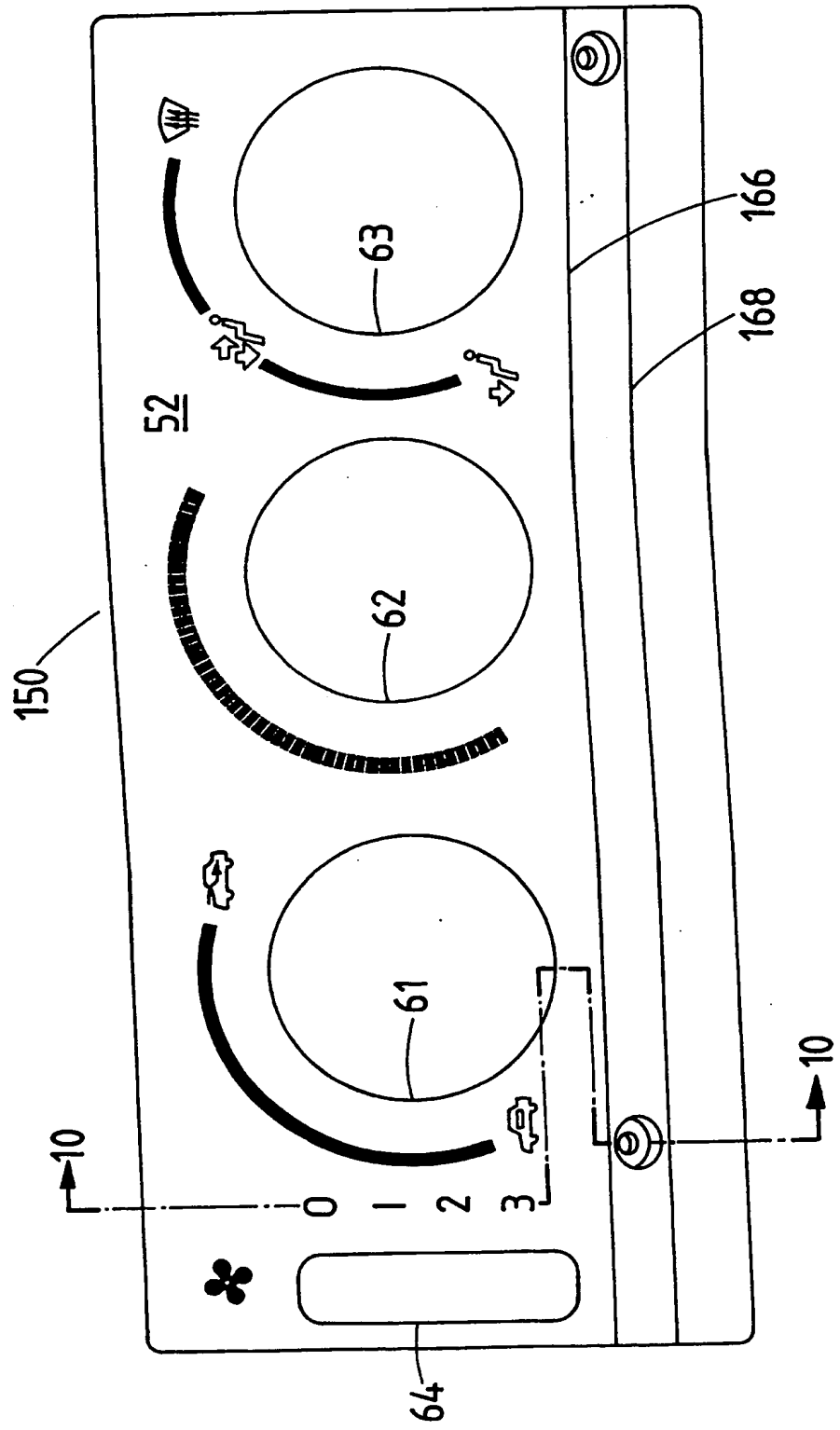


FIG. 9

FIG.10

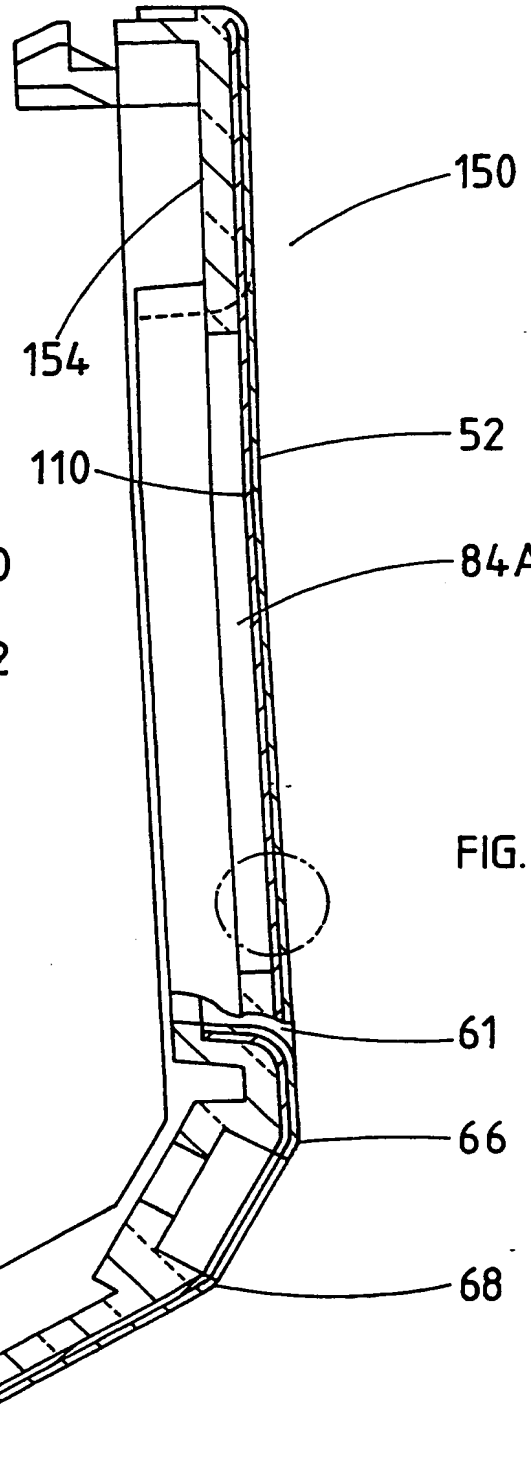


FIG.10a

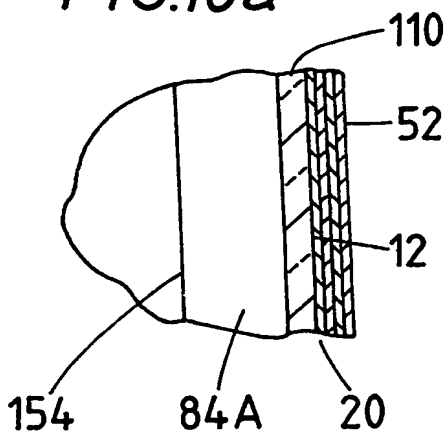


FIG.10a

A MOLDED APPLIQUE PRODUCT AND A METHOD OF MAKING THE SAME

This invention relates to molded applique products of the type made of synthetic resins having printing on a surface thereof and to a method of making the same. Products of this type are used, by way of example, to make automobile instrument panels.

Products of the indicated type have been made for many years by a method known in the art as an in-mold decorating process. This process, which has been in use since at least as early as 1972, was used to produce printed parts on polystyrene and polypropylene sheets that were, after printing, die cut and sent to injection molders to be in-molded into a finished product. By way of example, some of these products were plastic lunch boxes, pitchers, and canisters. In this process, the overlays or in-mold decoratives were produced by offset printing and/or screen printing, and the parts were flat and were held into the mold with a static charge. Because the overlays or in-mold decoratives did not contain complete (100 percent) ink coverage, it was possible to print on the rear surface of these parts and still have the molten plastic material fused to the rear surface of the plastic substrate, thus leaving a layer of plastic film on the outside to protect the graphics. In this process, the gating of the mold had to be such that the introduction of the plastic took place

where there was no ink, since any ink present in this area would tend to move or distort. The bonding in this case would only take place between the clear plastic area of the overlay and the molding compound itself.

A molding method essentially the same as the in-mold decorating process described above is disclosed in U.S. Patent No. 4,917,927. The patent claims novelty in the printing step wherein a synthetic resin sheet has an ink film applied to at least one side of the resin sheet wherein the ink film comprises one or more layers, each of which has a specific minimum thickness. The patent states that by this inking process that it is possible to produce a backlighting product. Backlighting products are well known in the art and are capable of making a pictorial image printed thereon look bright when viewed from the front if light is shown from the rear of the product. Products of this type are used to make automobile instrument panels. The patent discloses the printing on a flat resin sheet which is placed into a die into which a molten synthetic resin is injected pursuant to the in-mold technique discussed above.

The prior art techniques were not suitable for making a three-dimensional applique product of the type shown in the drawings. In fact, those skilled in the art believed it would not be possible to obtain the shape and configuration of this type while at the same time providing an acceptable decorative presentation. It was believed that

during the in-mold process of the prior art the product would be deformed and thereby harm the decorative presentation. However, specialized molding techniques hereinafter described allows the use of molten resin injection molding to form a three-dimensional product capable of being backlit which does not deform the decorative presentation. Additionally, the development of monomer resins which can be polymerized in situ as an alternative to molten thermoplastic injection molding is hereinafter disclosed which overcomes many of the problems associated with the injecting of molten plastic onto a printed substrate. One such development is the METTON® liquid-molding resin. METTON® is a registered trademark of Hercules, Inc. (Hercules Plaza, Wilmington, Delaware 19894-0001) for a proprietary blend of polydicyclopentadiene (PDCPD) formed by the metathesis polymerization of dicyclopentadiene (DCPD). The METTON® liquid molding resin involves the mixing of an "A" DCPD component with a "B" DCPD component within a mold cavity. The A and B DCPD components polymerize in situ to create polydicyclopentadiene at a reaction temperature of about 338°F (170°C) to about 392°F (200°C). METTON® resins have the advantage that less energy is required in the liquid molding of plastic parts than is needed for the thermoplastic injection molding thereof. Also, the polymerization reaction temperature of PDCPD is lower than the melt temperature of thermoplastic polymers whereby thinner

substrates and inks, which are less temperature deformable, can be utilized in the production of back-lit products.

It is a general object of this invention to provide a method of making applique products derived from synthetic resins. These products are obtained by fusing a resin behind a formed substrate in a molding process to produce a three-dimensional product having protruding portions, concave portions, or the like onto which indicia may be imprinted.

This general object is achieved by the following method:

(1) providing a flat substrate made of a clear synthetic resin;

(2) printing on the front surface of said substrate using a formable ink;

(3) pre-cutting the printed substrate to establish registration holes for a forming tool, this cutting step being performed, for example, by die cutting in a shearing machine;

(4) forming the printed substrate into a three dimensional shape, preferably by a cold-forming process to thereby reduce the internal stress from the internal form;

(5) providing a mold having a first surface of the same configuration as said formed substrate;

(6) die cutting the formed substrate so that it fits to the molding surface with minimal interference and such that the part can be placed in the die by reason of its configuration; and

(7) placing the formed substrate into the mold against said first mold surface and an injecting synthetic resin into the mold cavity located behind the formed substrate, which fuses with the formed substrate. In one embodiment of the invention, the fusion of step 7 is accomplished by injecting a molten synthetic resin such as a clear polycarbonate into the mold cavity located behind the formed substrate through a plurality of gates. In another embodiment of this invention, the fusion of step 7 is accomplished by simultaneously introducing two solutions of liquid DCPD directly behind the formed substrate through a plurality of gates, and polymerizing said DCPD solutions in situ within the mold cavity.

The above processes produce one-piece, permanently bonded applique products having the three-dimensional shaped configuration of the formed substrate.

There are some important parameters involved in the above-described embodiments. The thickness of the substrate material must be thick enough so as to isolate the inks from either the heat of the molten resin or the heat of reaction of the polymerizing DCPD solutions in the specific method described. Also, the ink used in the process must be a formable, high temperature ink that can

withstand the stresses of the form as well as the heat from either the molten resin or the heat from the polymerization of the two DCPD solutions during the in-molding process. Furthermore, the molding tools face (area where the front of the applique rests on the tool) should be maintained at temperatures specific to the fusion embodiment which is utilized. If fusion is accomplished using molten resin then the molding tool face should be maintained at a temperature of about 70°-110°F (21°-43°C) and the molten resin should not exceed 700°F (371°C). Additionally, each gate which supplies molten resin into the mold cavity should not supply an area greater than two square inches. If fusion is accomplished using in situ polymerization, the molding tool face should be maintained at a temperature of about 68°F-111°F (20°-44°C). Further, the rear portion of the molding tool (area which forms the mold cavity behind the substrate) should be maintained at about 140°-176°F (60°-80°C) and should have means to prevent DCPD polymerization over the area to be backlit in the finished product since PDCPD is not a clear polymer. Additionally, the two DCPD solutions should be maintained at a temperature of about 86°-95°F (30°-35°C) immediately prior to injection into the mold.

The important advantage of the above-described methods is that they are capable of producing three dimensional shaped products. Further, the use of cold-forming and the subsequent fusion of resin to a formed substrate makes it

possible to produce a product with reduced internal stress. The prior art methods cannot achieve this result. Further, the prior art, such as U.S. Patent No. 4,917,927, has not considered it possible to inject directly onto the printed applique substrate because of concern that a molten resin, with its high temperature and heat, will destroy the applique. However, in accordance with the invention, by utilizing the molten resin embodiment, the gates supply an area behind the formed substrate of only two square inches, thus, making it possible to reduce the heat and pressure within the mold cavity and still inject directly onto the applique. By utilizing the in situ polymerization embodiment, the liquid molding resin reaction temperature is lower than conventional thermoplastic resin molten temperatures, thus making it possible to reduce the process heat and pressures and thereby inject the liquid resin directly onto, and perpendicular to the surface of the applique. The advantage of injecting a resin directly by either embodiment is that it is not necessary to force a polymer resin into areas by increasing the pressure. The novel gating arrangement also makes it possible to design the mold with greater ease in that there is no restriction that the gates be located so as to prevent a material from impinging upon the applique surface in a fashion that would disrupt the applique. Also, by pre-forming the printed applique substrate and providing a molding tool as described above, there is no need to use the molding pres-

sures to create a product having a three-dimensional configuration.

Another object of the invention is to provide a novel molded applique product. Briefly stated, the novel product comprises a three-dimensional composite product having integral discrete printed symbols illuminatable when the product is back lit. The product is comprised of a synthetic resin substrate having a complex three-dimensional and non-regular geometric shape defining at least one opening, at least one ink layer printed on at least one surface of said substrate, said ink layer including multi-colored inks providing discrete symbols, and a synthetic resin layer fused with said pre-formed substrate. The resin layer back surface has integral protruding portions, and the resin layer defines at least one opening which corresponds to the opening of said substrate. The inks and the fused resin layer are arranged such that said discrete symbols printed on said substrate are illuminated when light is applied to the back surface of said resin layer.

Figure 1 is a front elevational view of a molded applique product made by molten resin injection molding in accordance with the invention.

Figure 2 is a section taken on line 2-2 of Figure 1.

Figure 2a is an enlarged detailed view of the circle portion shown in Figure 2.

Figure 3 is a plan view of a printed substrate in accordance with the invention.

Figure 4 is a perspective view of a formed substrate in accordance with the invention.

Figure 5 is a perspective view illustrating molten resin molding in accordance with the invention.

Figure 6 is a diagrammatic view of the molten resin molding shown in Figure 5.

Figure 7 is a perspective view illustrating in situ polymerization in accordance with the invention.

Figure 8 is a diagrammatic view of the in situ polymerization molding shown in Figure 7.

Figure 9 is a front elevational view of a molded applique product made by in situ polymerization molding in accordance with the invention.

Figure 10 is a section taken on lines 10-10 of Figure 9.

Figure 10a is an enlarged detailed view of the circle portion shown in Figure 10.

An initial step in accordance with a preferred embodiment of the method of the invention is to provide a flat substrate of a synthetic resin such as polycarbonate. The substrate is indicated generally at 10 in Figure 3.

The next step in the method is to print the desired design on the front surface 12 of substrate 10 using

formable ink. Suitable inks that can be used are solvent based polyester inks that adhere to synthetic resins such as polycarbonate. As shown in Figure 3, a printed design indicated generally at 14 is provided in a rectangular configuration. The printing step is performed by the making of a plurality of printing passes wherein a single color is applied during the running of each path. The different colors are also applied in the circular areas shown in Figure 3 located above the printed design 14, which areas 16 form no part of the completed product as will be described hereafter. Also, a plurality of marks 18 for registration holes are printed at locations located around the printed design 14 as is apparent in Figure 3.

The next step is the shearing step wherein the printed substrate 10 is precut into rectangles and has a plurality of registration holes (at marks 18) punched therein. This step produces a printed part that is prepared to be used in a forming tool whereby it is shaped to fit within the tool and to register with the registration pins of said tool. This step is preferably performed in a shearing machine.

The next step is the forming step wherein the precut printed substrate is formed into a three-dimensional shape, such as the formed substrate 20 illustrated in Figure 4. The forming step is preferably performed by a cold forming process to thereby reduce the internal stress from the internal form. In this step, the flat sheet is placed into a forming press which is run through its forming cycle to

form the sheet into the three-dimensional shape desired, which shape can have, as illustrated in Figure 4, a non-regular geometric shape defining openings and comprising a bent configuration including a pair of obtuse angles and protruding portions or concave portions.

The next step is to cut the formed substrate 20 into a configuration such that it fits into the die used in the molding step to be performed hereafter in a manner that the configuration of the formed substrate 20 serves to hold it in place. Thus, the formed substrate 20 must be cut so that it fits into the molding tool with a minimal interference fit.

The next step in the method is the insert molding step. In the molten resin injection molding embodiment, the formed substrate 20 is placed into the cavity 32 of the molding tool 30 against the front mold surface 34 and the mold is closed to hold substrate 20 in a position as illustrated in Figure 5. The molding tool 30 provides a cavity 32 which includes a first surface 34 that has the same configuration as that of the formed substrate 20. The molding tool 30 is formed of a front half 36 and a back half 38 which are secured together to define the mold cavity 32 therebetween. The back mold half 38 is provided with three gates 41, 42, and 43 through which the synthetic resin is introduced into the bottom of the cavity 32. The three gates 41, 42, and 43 extend in a direction perpendicular to the mold cavity 32.

After placement of the formed substrate 20 into cavity 32, a clear molten polycarbonate resin is injected into the mold cavity space located behind the formed substrate. This step is achieved by introducing the molten resin in the bottom of cavity 32 directly behind the formed substrate through the three gates 41, 42, and 43 constructed and arranged in the manner as described above so that each gate 41, 42, and 42 does not supply molten resin to an area of mold cavity 32 greater than two square inches. Figure 6 illustrates the flow of the molten resin upwardly within cavity 32.

The above-described method produces a one-piece permanently bonded applique product having the three-dimensional shaped configuration of the formed substrate 20 as is apparent from Figures 1 and 2 which illustrates the molded applique product 50. Thus, the product 50 comprises a front wall comprising formed substrate 20, which includes a plurality of printed layers 52 which are applied to the front face 12 of the substrate 10, and a back wall comprising the clear polycarbonate resin substrate 54.

Referring to Figures 1 and 2, wherein a novel product in accordance with the invention is disclosed in detail, it will be noted that there is provided a three-dimensional composite product 50 having integral discrete symbols illuminatable when the product is back lit. The synthetic resin substrate 20 has a complex three-dimensional and non-regular geometric shape defining three circular openings

61, 62, 63, and a generally rectangular-shaped opening 64. As discussed above, the substrate 20 is pre-formed and has a front surface and a back surface as best illustrated in Figure 2A.

The substrate has at least one ink layer printed on at least one surface thereof. More particularly, the ink layer includes multi-colored inks providing discrete symbols as is shown in Figures 1, 2, and 2a.

The product 50 also comprises a synthetic resin layer 54 fused with the pre-formed substrate 20 which layer 54 has a front surface and a back surface. The front surface of synthetic resin layer 54 mates with the back surface of substrate 20. The back surface of synthetic resin layer 54 has integral protruding portions as shown in Figure 2. Also, the synthetic resin layer 54 defines four openings which correspond to the four openings 61-64, respectively, in the substrate 20.

It will be noted that the inks and the resin layer 54 are arranged such that discrete symbols printed on the substrate 20 are illuminated when light is applied to the back surface of the resin layer 54 as is apparent from a consideration of Figures 1, 2, and 2a.

As is illustrated in Figures 1 and 2, the openings 61-63 in the pre-formed substrate 20 are formed by a rounded portion of the substrate 20 projecting rearwardly from said front surface thereof. The rounded portion of the substrate 20 forming opening 61 includes a rearwardly extend-

ing portion and a curved portion forming a rounded edge with the rearwardly extending portion being joined with said curved portion to form the opening 61. Openings 62 and 63 have the same construction as opening 61.

It will also be apparent from a consideration of Figures 1 and 2 that the product 50 is shaped to provide two obtuse angles, indicated generally at 66 and 68 as is best shown in Figure 2.

In the in situ polymerization embodiment, the formed substrate 20 is placed into the cavity 132 of the molding tool 130 against the front mold surface 134 and the mold is closed to hold substrate 20 in a position as illustrated in Figure 7. The molding tool 130 provides a cavity 132 which includes a first surface 134 that has the same configuration as that of the formed substrate 20. The molding tool 130 is formed of a front half 136 and a back half 138 which are secured together to define the mold cavity 132 therebetween. The back mold half 138 is provided with gates 141, 142, and 143 through which the DCPD solutions are introduced into the bottom of cavity 132. The three gates 141, 142, and 143 extend in a direction perpendicular to the mold cavity 132. After placement of the formed substrate 20 into cavity 132, a 1:1 ratio of METTON® "A" DCPD and METTON® "B" DCPD solutions are simultaneously injected into the bottom of cavity 132 directly behind the formed substrate through the three gates 141, 142, and 143 as shown in Figure 7. Figure 8 illustrates the flow of the combined

monomer solutions upwardly within cavity 132. An important aspect of the molding step is shown in Figures 4 and 8. PDCPD is not transparent. Therefore, it is important that polymerization of the DCPD solutions is prevented behind the areas of the substrate 20 which are to be backlit in the finished product such as 71, 72, 73, 74, and 75 shown in Figure 4. To prevent polymerization over these areas, the back half 138 of mold 130 has projections which extend from the back half 138 of mold 130 to contact the back portion of the formed substrate 20 to cover areas 71-75 during the polymerization step. These projections are shown in Figure 8 as mold projections 81, 82, 83, 84, and 85 which cover areas 71, 72, 73, 74, and 75, respectively, on substrate 20 during polymerization in the mold 130. Projections 81-85 prevent polymerization over areas 71-75, respectively, thereby leaving gaps in the opaque PDCPD and thereby allowing areas 71-75 to be backlit when light is applied to the back side of the finished product. During the in situ polymerization embodiment molding step, the front half 136 of molding tool 130 should be maintained at a temperature of about 68°-111°F (20°-44°C). The back half 138 of mold tool 130 should be maintained at a temperature of about 140°-176°F (60°-80°C) and the "A" DCPD and the "B" DCPD solutions should be maintained at a temperature of about 86°-95°F (30°-35°C) immediately prior to injection into mold cavity 132. The polymerization reaction tempera-

ture is about 338°-392°F (170°-200°C) and the polymerization reaction rate is about 1.5 kg/sec.

The above-described method produces a one-piece permanently bonded applique product having the three-dimensional shaped configuration of the formed substrate 20 as is apparent from Figures 9 and 10 which illustrates the molded applique product 150. Thus, the product 150 comprises a front wall comprising formed synthetic resin substrate 20, which includes a plurality of printed layers 52 which are applied to the front face 12 of the substrate 20, and a back wall comprising the PDCPD 154 having gaps in the PDCPD 154 over areas of the printed layers 52 which are to be backlit such as gap 84A shown in Figures 10 and 10a provided by mold projection 84 during the molding step.

Referring to Figures 9 and 10, wherein a novel product in accordance with the invention is disclosed in detail, it will be noted that there is provided a three-dimensional composite product 150 having integral discrete symbols illuminatable when the product is back lit. The synthetic resin substrate 20 has a complex three-dimensional and non-regular geometric shape defining three circular openings 61, 62, 63, and a generally rectangular-shaped opening 64. As discussed above, the substrate 20 is pre-formed and has a front surface and a back surface as best illustrated in Figure 10A.

The substrate has at least one ink layer printed on at least one surface thereof. More particularly, the ink

layer includes multi-colored inks providing discrete symbols as is shown in Figures 9, 10, and 10a.

The product 150 also comprises a synthetic resin layer 154 fused with the pre-formed substrate 20 which layer 154 has a front surface and a back surface. The front surface of synthetic resin layer 154 mates with the back surface of substrate 20. The back surface of synthetic resin layer 154 has integral protruding portions as shown in Figure 10. Also, the synthetic resin layer 154 defines four openings which correspond to the four openings 61-64, respectively, in the substrate 20.

It will be noted that the inks and the resin layer 154 are arranged such that discrete symbols printed on the substrate 20 are illuminated when light is applied to the back surface of the resin layer 154 as is apparent from a consideration of Figures 9, 10, and 10a and from the discussion above of the gaps in the resin layer 154 over areas to be backlit.

As is illustrated in Figures 9 and 10, the openings 61-63 in the pre-formed substrate 20 are formed by a rounded portion of the substrate 20 projecting rearwardly from said front surface thereof. The rounded portion of the substrate 20 forming opening 61 includes a rearwardly extending portion and a curved portion forming a rounded edge with the rearwardly extending portion being joined with said curved portion to form the opening 61. Openings 62 and 63 have the same construction as opening 61.

It will also be apparent from a consideration of Figures 9 and 10 that the product 150 is shaped to provide two obtuse angles, indicated generally at 66 and 68 as is best shown in Figure 10.

Specific examples pursuant to the invention are set forth below:

EXAMPLE I

The parts were printed, seven-up, on a 22 inch by 31 inch, 0.020 inch (558.8 cm by 787.4 cm, 0.508 cm) thick polycarbonate sheet, all printing being a front surface operation. Below is a list of the passes and the specifications for running these passes:

PASS	INK	DRY TIME	SCREEN	EMULSION	BLADE
1. Pinhole	40070306 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
2. Green	40070271 Mylar	3.0 hrs.	270 Wire	Direct	85 D. Sharp
3. White	40070307 Mylar	3.0 hrs.	270 Wire	Direct	85 D. Sharp
4. Yellow	40070313 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
5. Red	40070314 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
6. Blue	40070317 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
7. Graphics	40070306 Mylar	3.5 hrs.	270 Wire	Indirect/ Direct	85 D. Sharp

The inks selected were all solvent based polyester inks adherable to polycarbonate and of a type that can withstand the stresses of the forming steps as well as the temperature of the resin injection step described hereinafter.

During the printing process, the parts are coated to provide for scratch and solvent resistance.

After printing, the parts were sheared into rectangles for use in a one cavity forming tool. Registration holes were punched in the parts at this time also, whereby the parts were ready for the forming press.

The forming step was performed in a one cavity tool. Each part was placed on the tool's registration pins by inserting the pins within the registration holes previously punched therein and the part was then formed. The forming procedure involved the following steps:

1. The tool was placed on the shuttle table that enters the press.
2. A "slow-close" technique was used to set the machine to the configuration of the tool.
3. Pressures were then set to 4,000 pounds (1814 kilograms).
4. Parts were then placed on the tool using the registration pins established.
5. The parts were then run through the forming cycle two times and then removed.

In the next step, i.e., the cutting step, the parts were laser cut to a desired size so as to fit properly in the molding tool.

After cutting, the parts were placed by hand into the molding tool, with the configuration of the form serving to hold the part in place. Caution was taken that the part sits flush with the forming tool. The head of the tool whereat the applique sits was cooled to 70°F (21°C) using cooling lines and the molten polycarbonate resin was set to 700°F (371°C) at 500 psi (35.2 kg/59.0 cm). The resin was then injected into the mold cavity behind the printed part. During operation, the pressures and temperatures in the molding process were held as low as possible to reduce the chances of the ink running.

The part was then removed from the die and masked in the back thereof at all locations with the exception of the graphic areas. This reduced the possibility of pin holes.

Each part was then examined for suitability for shipment.

EXAMPLE II

The parts were printed, seven-up, on a 22 inch by 31 inch, 0.020 (558.8 cm by 787.4 cm, 0.508 cm) inch thick polycarbonate sheet, all printing being a front surface operation. Below is a list of the passes and the specifications for running these passes:

PASS	INK	DRY TIME	SCREEN	EMULSION	BLADE
1. Pinhole	40070306 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
2. Green	40070271 Mylar	3.0 hrs.	270 Wire	Direct	85 D. Sharp
3. White	40070307 Mylar	3.0 hrs.	270 Wire	Direct	85 D. Sharp

4.	Yellow	40070313 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
5.	Red	40070314 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
6.	Blue	40070317 Mylar	3.5 hrs.	270 Wire	Direct	85 D. Sharp
7.	Graphics	40070306 Mylar	3.5 hrs.	270 Wire	Indirect/ Direct	85 D. Sharp

The inks selected were all solvent based polyester inks adherable to polycarbonate and of a type that can withstand the stresses of the forming steps as well as the temperature of the in-situ polymerization step described hereinafter.

During the printing process, the parts are coated to provide for scratch and solvent resistance.

After printing, the parts were sheared into rectangles for use in a one cavity forming tool. Registration holes were punched in the parts at this time also, whereby the parts were ready for the forming press.

The forming step was performed in a one cavity tool. Each part was placed on the tool's registration pins by inserting the pins within the registration holes previously punched therein and the part was then formed. The forming procedure involved the following steps:

1. The tool was placed on the shuttle table that enters the press.
2. A "slow-close" technique was used to set the machine to the configuration of the tool.

3. Pressures were then set to 4,000 pounds (1814 kilograms).
4. Parts were then placed on the tool using the registration pins established.
5. The parts were then run through the forming cycle two times and then removed.

In the next step, i.e., the cutting step, the parts were laser cut to a desired size so as to fit properly in the molding tool.

After cutting, the parts were placed by hand into the molding tool, with the configuration of the form serving to hold the part in place. Caution was taken that the part sits flush with the forming tool. The head of the tool whereat the applique sits was heated and maintained at 140°-176°F (60°C-80°C) using heating lines and METTON® "A" DCPD and METTON® "B" DCPD monomer solutions were maintained at 86°-95°F (30°C-35°C) prior to injection. The two monomer solutions were then simultaneously injected into the mold cavity behind the printed part.

The part was then removed from the die and masked in the back thereof at all locations with the exception of the graphic areas. This reduced the possibility of pin holes.

Each part was then examined for suitability for shipment.

While the preferred embodiment has been fully described and depicted for the purposes of explaining the principles of the present invention, it will be appreciated by those skilled in the art that modifications, substantiations, and changes may be made thereto without departing from the scope of the invention set forth in the appended claims.

CLAIMS

1. A method of making an applique product derived from synthetic resins by an in-situ polymerization molding process so as to produce a three-dimensional product, said method comprising the steps of:

(1) providing a flat substrate having a front surface and a back surface, said substrate being made of a synthetic resin,

(2) printing on at least one surface of said substrate,

(3) preparing the printed substrate for forming,

(4) forming the printed substrate into a three dimensional shape to produce a formed substrate having low internal stress,

(5) providing a mold cavity in which at least one mold surface has the same configuration as the front surface of said formed substrate,

(6) conforming said formed substrate to fit securely into said mold cavity,

(7) placing the formed substrate into said mold cavity in such manner that the front surface of said formed substrate is in contact with said mold surface whereupon the mold is then closed for conducting the molding operation,

(8) simultaneously injecting two flowable monomer resin solutions into the cavity located adjacent said back surface of said formed substrate through gate means, said resin being constituted so as to polymerize in situ and fuse with said back surface.

2. A method of making applique products according to claim 1, wherein the forming of the printed substrate of step (4) is performed by a cold forming process that results in low internal stress in the formed substrate.

3. A method of making applique products according to claim 1 or 2 wherein the two injected resin solution of step (8) are dicyclopentadiene resin solutions.

4. A method of making applique products according to any preceding claim wherein the inks in the printing step (2) are formable inks capable of withstanding the stresses of the forming step (4) as well as the polymerisation reaction temperatures of step (8) without deforming.

5. A method of making applique products according to any preceding claim wherein a plurality of inks of multiple colors are used in the printing step (2).

6. A method of making applique products according to any preceding claim wherein said formed substrate is dimensioned to achieve a minimal interference fit when placed in the cavity of the mold with its front surface in contact with the mold surface in step (7) so that said formed substrate will not move during the injection of resin according to step (8).

7. A method of making applique products according to any preceding claim wherein the injecting of two flowable monomer resin solutions into the cavity space according to step (8) is achieved by the use of gate means wherein a plurality of gates are located so that the two resin solutions flow directly onto the formed substrate in a direction perpendicular thereto.

8. A method of making applique products according to any preceding claim wherein said mold surface in step (8) is maintained at a temperature that will not damage said inks and said resin temperature does not exceed 200°C.

9. A method of making applique products according to any preceding claim wherein said substrate is made of a clear polycarbonate.

10. A method of making an applique product substantially as herein described with reference to the accompanying drawings.

11. An applique product made according to the method of any preceding claim.

12. A three-dimensional composite product having integral discrete printed symbols illuminatable when said product is back lit comprising:

a synthetic resin substrate having a three-dimensional geometric shape defining at least one opening, said substrate being pre-formed and having a front surface and a back surface;

at least one ink layer printed on at least one surface of said substrate, said ink layer including multi-colored inks providing discrete symbols; and

a synthetic resin layer fused with said pre-formed substrate and having a front surface and a back surface, said resin layer front surface mating with said substrate back surface, said resin layer back surface having integral protruding portions, and said resin layer defining at least one opening which corresponds to said opening of said substrate;

said inks and said resin layer being arranged such that said discrete symbols printed on said substrate are illuminated when light is applied to said back surface of said resin layer.

13. A three-dimensional composite product according to claim 12 wherein said opening in said preformed substrate is formed by a rounded portion of said substrate projecting rearwardly from said front surface thereof.

14. A three-dimensional composite product according to Claim 13 wherein said rounded portion of said substrate includes a rearwardly extending portion and a curved portion forming a rounded edge, said rearwardly extending portion being joined with said curved portion to form said opening.

15. A three-dimensional composite product according to Claim 14 wherein said opening has a circular shape.

16. A three-dimensional composite product according to Claim 14 wherein said opening has a generally rectangular shape.

17. A three-dimensional composite product according to Claim 14 wherein there are provided a plurality of said openings.

18. A three-dimensional composite product according to Claim 12 wherein said preformed substrate is shaped to provide at least one obtuse angle.

19. A three-dimensional composite product having integral discrete printed symbols illuminatable when said product is back lit comprising:

a synthetic resin substrate having a complex three-dimensional geometric shape, said substrate being preformed and having a front surface and a back surface;

at least one ink layer printed on at least one surface of said substrate, said ink layer including multi-colored inks providing discrete symbols; and

a synthetic resin layer fused with said pre-formed substrate and having a front surface and a back surface, said resin layer front surface mating with said substrate back surface, said resin layer back surface having integral protruding portions,

said inks and said resin layer being arranged such that said discrete symbols printed on said substrate are illuminated when light is applied to said back surface of said resin layer.

20. A three-dimensional composite product according to Claim 12 wherein said synthetic resin layer is fused with said pre-formed substrate by the polymerization of said synthetic resin layer.

21. A three-dimensional composite product of Claim 20 wherein said synthetic resin layer is polydicyclopentadiene.

22. A three-dimensional composite product according to Claim 19 wherein said synthetic resin layer is fused with said pre-formed synthetic resin substrate by the polymerization of said synthetic resin layer.

23. A three-dimensional composite product according to Claim 22 wherein said synthetic resin layer is polydicyclopentadiene.

24. A three-dimensional composite product according to Claim 12 wherein said synthetic resin layer is fused with said pre-formed synthetic resin substrate by the thermoplastic injection of said synthetic layer.

25. A three-dimensional composite product according to Claim 24 wherein said synthetic resin layer is polycarbonate.

26. A three-dimensional composite product according to Claim 19 wherein said synthetic resin layer is fused with said pre-formed synthetic resin substrate by the thermoplastic injection of said synthetic layer.

27. A three-dimensional composite product according to Claim 26 wherein said synthetic resin layer is polycarbonate.

28. A three-dimensional composite product substantially as herein described with reference to the accompanying drawings.

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J P LEIGHTON

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Databases (see below)
(i) UK Patent Office collections of GB, EP, WO and US patent specifications.

(ii) ONLINE DATABASES: WPI

Documents considered relevant following a search in respect of Claims :-
1-11

Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

&: Member of the same patent family; corresponding document.

Category	Identity of document and relevant passages		Relevant to claim(s)
Y^1	GB 2261187 A	(KAUMAGRAPH FLINT) Whole disclosure	1 at least
Y^1	GB 2259884 A	(ROVER GROUP) Whole disclosure	1 at least
Y^2	GB 2148786 A	(ARMITAGE SHANKS) See page 1 lines 44-82	1 at least
Y^2	GB 2082961 A	(COMIND) See page 2 lines 24-52	1 at least
Y^1	GB 1404443	(LAPARRA) Whole disclosure	1 at least
Y^1	GB 1330281	(GENERAL TIRE & RUBBER CO) Whole disclosure	1 at least

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